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# *Technical Approach of the End to End Deployment Simulation (E2EDS)*

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# Outline

- Capability Required
- Capabilities Developed
  - E2EDS
  - Installations
  - Agents
- Advantages, Challenges
- Lessons Learned, Next Steps
- Key Points



# Capability Required

- Ability to assess impacts on deployment (and other installation processes) due to changes of:
  - Infrastructure
  - Unit selection (personnel/equipment)
  - Resources
  - Policies/procedures
- Extended to End-to-End Deployment Simulation
  - Include installation capability, plus assessing impacts at forward locations



# Questions

- *How does unit readiness affect the time and resources required to deploy?*
- *How does resource allocation impact the time it takes units to deploy?*
  - *Where are chokepoints?*
  - *Where is excess capacity?*
- *How does the physical location of deployment facilities in relation to others impact the time required to deploy?*
- *How do proposed process changes impact the time and resources required to deploy?*

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- *What is the resource contention between multiple units deploying at the same time?*
- *How does force mix (warfighting versus support units) impact throughput in the deployment pipeline?*

# Challenges of Modeling Deployments

- Non-standard execution
- Installations are unique
  - Different requirements
  - Status/readiness of Units (personnel, equipment, and vehicles)
  - Training requirements
  - Transportation assets
  - Facilities
- Capability shift (installation ➔ E2E)

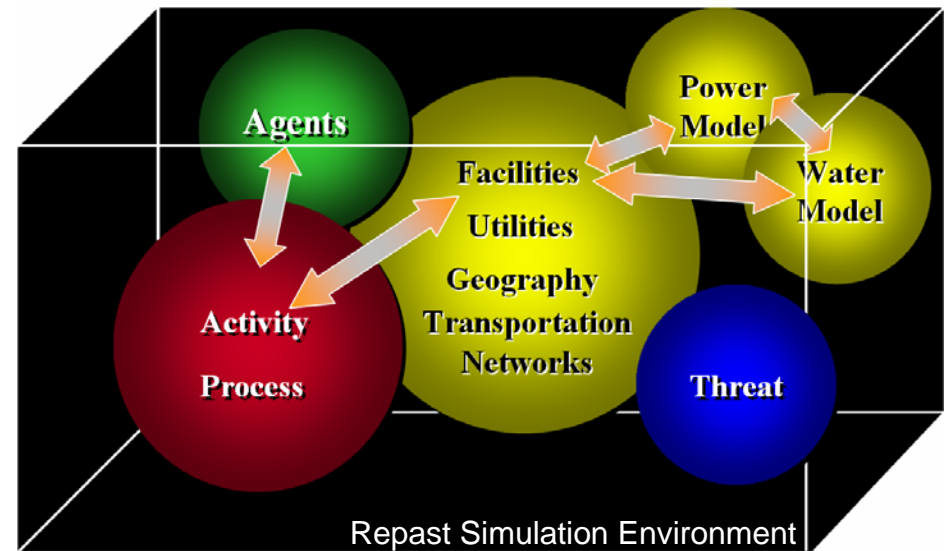


# Capability Developed

## Developed the Virtual Installation

–Each node as a discrete-event simulation integrating:

- GIS (infrastructure)
- Physics-based utility models (power, water)
- Agent-based modeling (personnel, equipment, resources)
- Behavior-oriented design (processes)

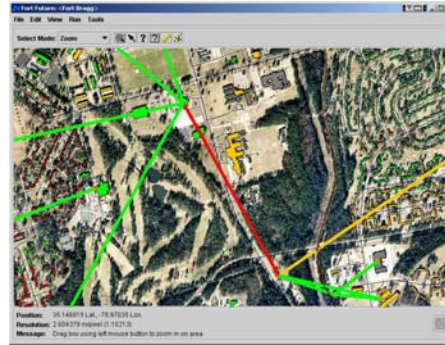




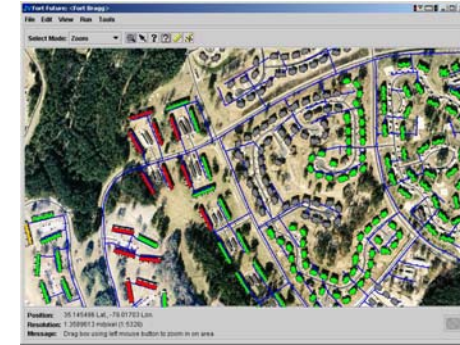
# Virtual Installation



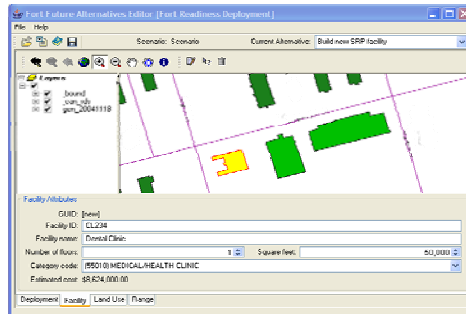
**Deployment**  
(personnel, equipment, processes)



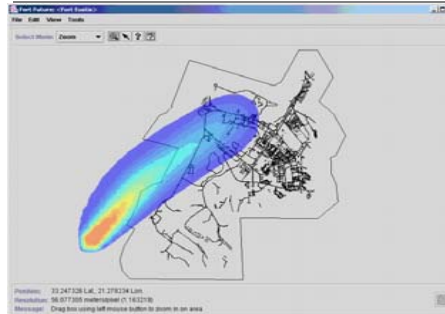
**Electrical Infrastructure**  
(capacity, interruption)



**Water Infrastructure**  
(flow, CBR)



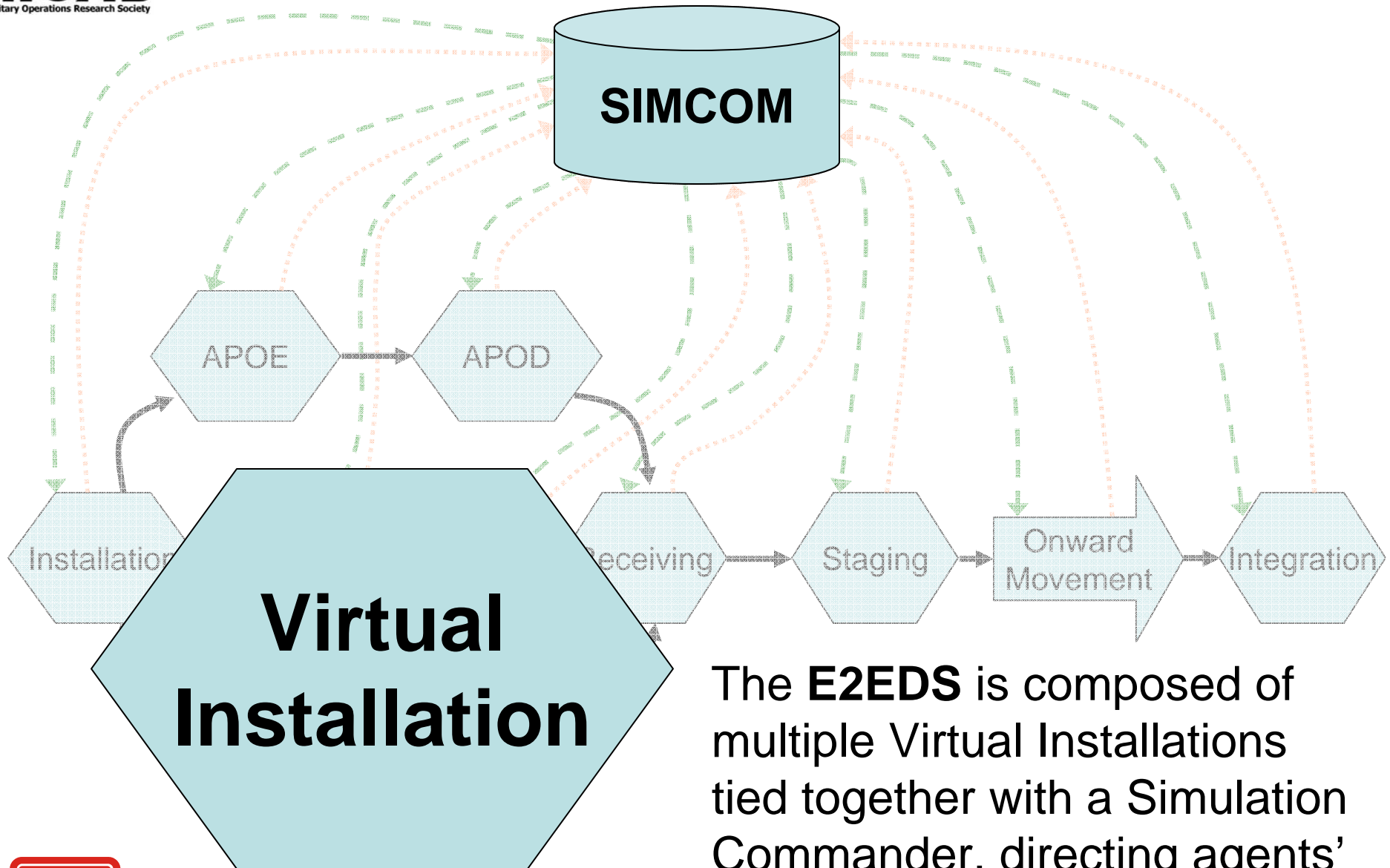
**Facility Siting**



**CBR Plume Modeling**

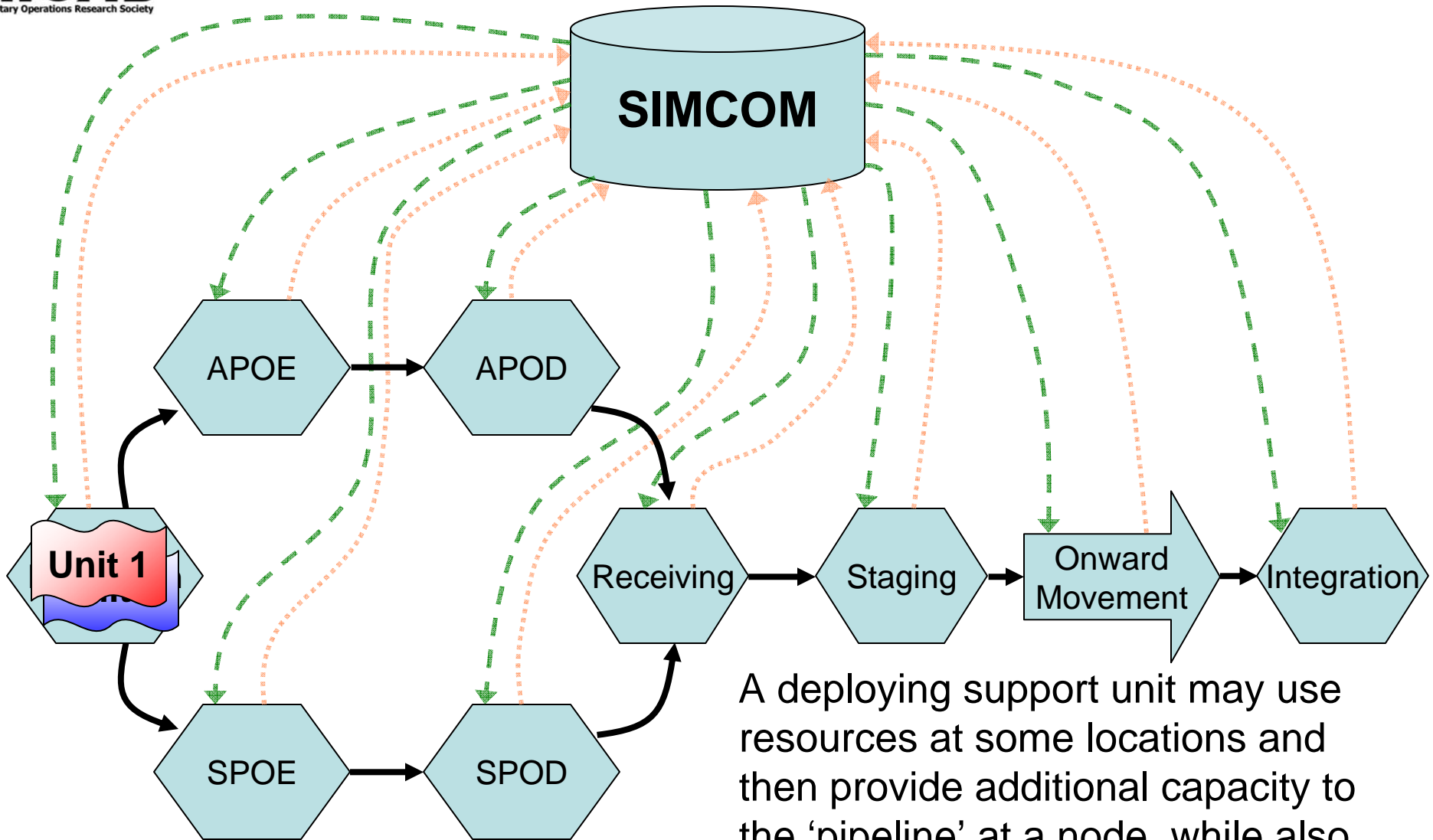


**Collaborative Web-based Decision Support**



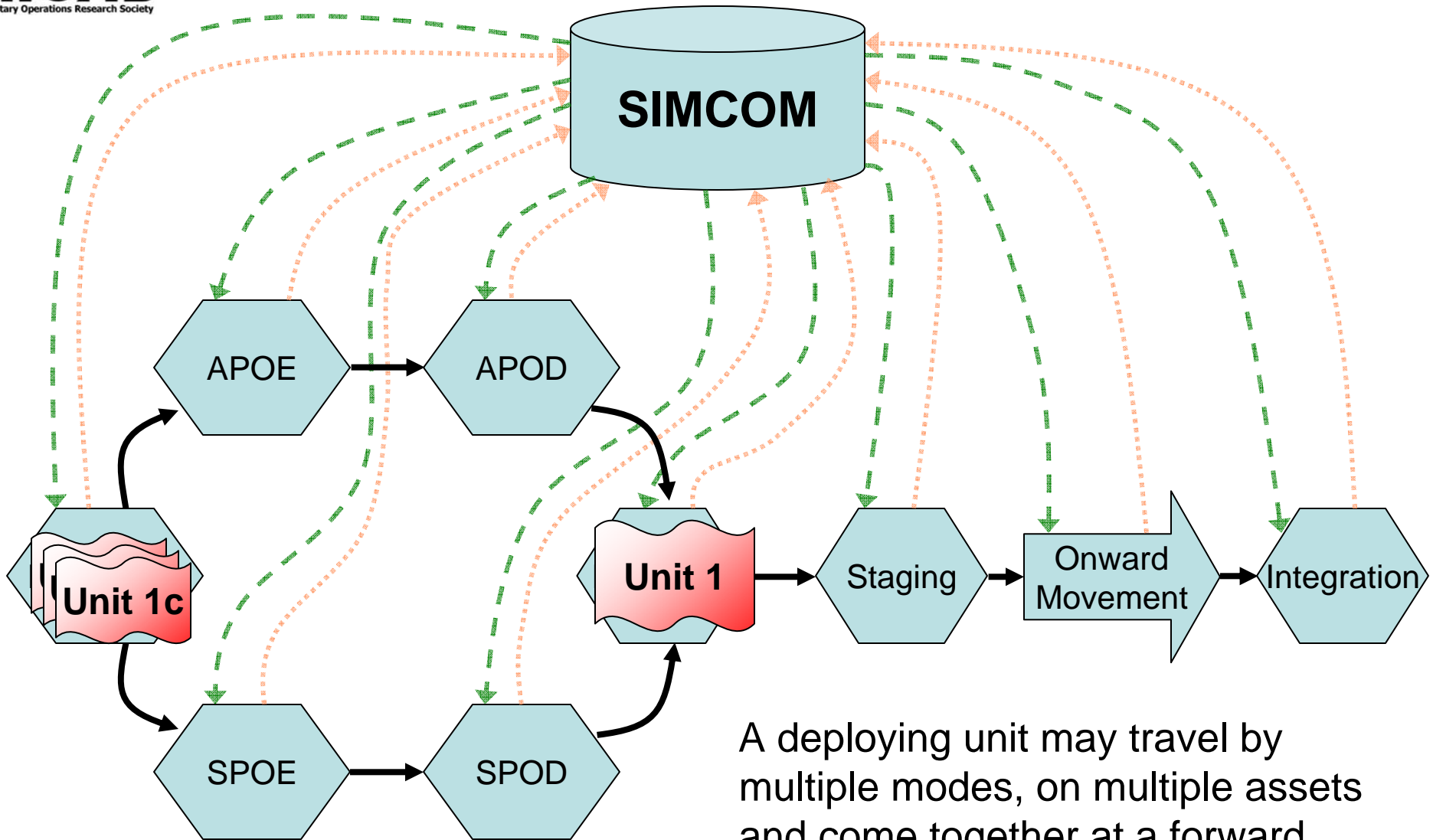
The **E2EDS** is composed of multiple Virtual Installations tied together with a Simulation Commander, directing agents' movements between locations.





A deploying support unit may use resources at some locations and then provide additional capacity to the 'pipeline' at a node, while also consuming certain resources at the node.





A deploying unit may travel by multiple modes, on multiple assets and come together at a forward location and then move as a single unit.



# Macro Simulation Parameters

- Establish the nodes (e.g., Installations)
  - GIS, XML Specifications
- Unit METL -> Unit Goals -> Unit Plan
  - (define movement schedule, goals)
- Load / Create the unit actions that satisfy the requirements of the goal
- Load / Select / Create units
  - Contain attributed soldiers, vehicles, and equipment
  - Unit attribution is based on real unit characteristics
    - E.g., level of readiness, capabilities, specialties, etc.
    - Or generic units...



# Micro Simulation Parameters

## Within Virtual Installation

- Specific locations (e.g., Motorpool) in each macro node (e.g., Home Installation), including reactive plans for agents at the locations
- Select / Create potential events within nodes
  - Nested reactive plans, influencing agent behavior if the event takes place



# Behavior-Oriented Design Approach

- BOD is based on agents that have multiple, sometimes conflicting goals, and a decision-making process to arbitrate which behavior to act upon based on:
  - Goals and state of self
  - State of the environment
- Implemented with variant of Parallel-rooted, Ordered Slip-stack Hierarchical Reactive Plan (POSH)
  - Dr. Joanna Bryson, University of Bath, United Kingdom
- Modified to Enhanced Shared Reactive Plans (ESReP)



# Role of the Individuals

## *Variability in human behavior impacts deployments*

- Actions of a single soldier can be critical
- Knowledge, training and skill of the individual soldier
- Multiple roles of individual soldiers
- Interactions with the environment
- Reactions to events contrary to the plan





# Enhanced Shared Reactive Plans (ESReP)

ESReP is a good way to model deployments

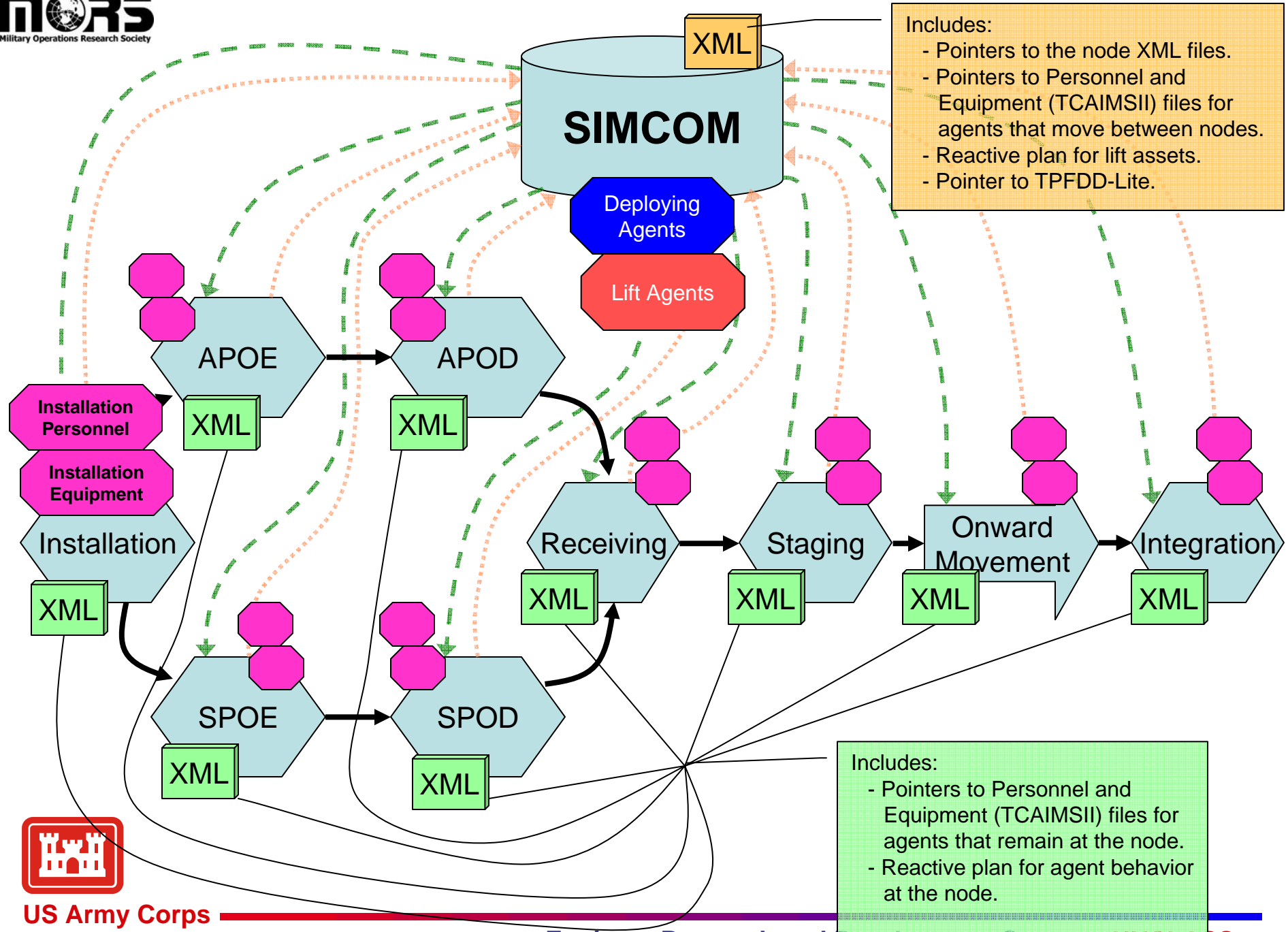
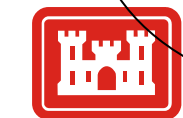
- Implicit in a Reactive Plan is a priority ordering to the sequences of tasks and the preconditions (or triggers) that activate them.
- Military deployments involve complex sets of concurrent and sequential tasks.
- Agent behaviors in deployment modeling are well-addressed with reactive plans because deployments are planned, structured, and *similar* from one deployment to another.
  - Typically, variants are units, locations, sometimes processes
- Drives multiple agents without redundant plan creation



# Enhanced Shared Reactive Plans (ESReP)

- Implemented using XML
- Discrete-event
- Stochastic
  - Participation
  - Durations
  - Activity/Task/Event Results
- Sensing
  - Other agents
  - Environmental
- Actions based on attributes

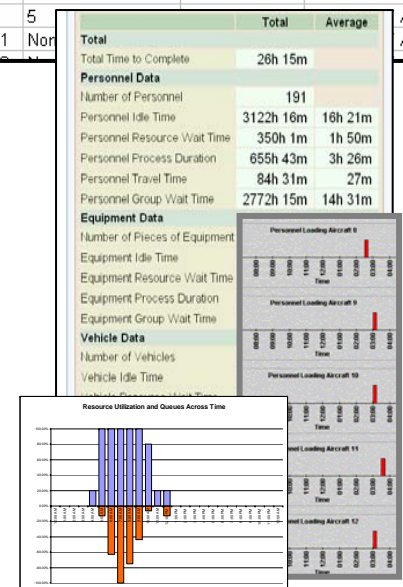




# Evaluation

- Courses of action
- End-to-end force flow (teeth v. tail) – resource sufficiency?
- Time utilization of units overall, individuals
  - Officers have time for planning?
- Process efficiencies
  - Individuals causing delays?
  - Officers go first through lines?
  - Too much positive control (direct order v. discretion)?
- Resource efficiency (Underused or overworked resources?)
- Vulnerability
- Examine individual agents / types of agents
- Facility selection

Installation	Agent ID	Agent Type	Field Name	From	To	Date	Time
Fort Readiness	PIDB1B009	Person	resourceType	none	driver_tc	1/1/2010	5:29:34 AM
Fort Readiness	PIDB1B010	Person	Recall_status	1	2	1/1/2010	1:54:14 AM
Fort Readiness	PIDB1B010	Person	Recall_status	2	3	1/1/2010	2:24:14 AM
Fort Readiness	PIDB1B010	Person	Movement_status	none	Need_bus_to_SRP	1/1/2010	5:12:16 AM
Fort Readiness	PIDB1B010	Person	Recall_status	3	4	1/1/2010	5:12:16 AM
Fort Readiness	PIDB1B010	Person	End_loc	none	4101	1/1/2010	5:12:16 AM
Fort Readiness	PIDB1B010	Person	Start_loc	2102	2102	1/1/2010	5:12:16 AM
Fort Readiness	PIDB1B010	Person	Recall_status	4	5		
Fort Readiness	PIDB1B010	Person	End_loc	4101	Nor		



# Advantages/Challenges

## Advantages of E2EDS

- Integrated
  - GIS, infrastructure models, process models
- Agent-based capabilities
  - interacting agents, sensing changes
- Transparent
  - record of agent actions, decision criteria
- Output
  - database, logs
- Standard inputs
  - geospatial, soldier records, etc.
- Reusable components
  - GIS and unit data swap-out, processes



# Advantages/Challenges

## Challenges of E2EDS

- Still a 6.2 project
- Changes to certain details may mean customization effort
- Needs additional development
  - Data acquisition
  - Processes / decision-making
  - Time and readiness distributions



# Next Steps

- Collaboration for interim staging base
- Document template processes available in the E2EDS
- Partnering
  - Reactive plan development
  - Expand modeled activities (processes, senses)
  - Infrastructure models



# Deployment Modeling

## Lessons Learned

- Need more than a typical discrete-event simulation package
  - Deployment modeling should go beyond standard DES (single tasks or short-tons) – need behaviors, interactions
  - No link to utility, plume models, or accept GIS input
- Need agent-based simulation  
(Distributed Information Architecture System (DIAS))
  - Reactive behavior enhances capabilities, enhancing decision-making
  - Allowed wrapping of other models (utilities and plume)
  - Agents need to be more aware of and interact with other agents, as well as be aware of when their role should change
- Need to be aware of other agents/environment, better interaction  
(Repast-Simphony)
  - Used to create an Agent-based Discrete Event Simulation
  - Preserves wrapping of external models and ESReP
  - Allows for sensing the environment





# Technical Key Points

## The E2EDS – multiple Virtual Installations

- Discrete-event simulation integrating:
  - GIS (infrastructure)
  - Physics-based utility models (power, water)
  - Agent-based modeling (personnel, equipment, resources)
  - Behavior-oriented design (processes)
- Atypical Developments
  - Able to represent entities as resources, vice-versa
  - Integrated physics-based models of infrastructure, with agent-based models of personnel, equipment
  - Scenario rapidly adaptable (units, facilities, details)



# Questions?

